is so, because the chemists among us are for the most part silent, and chemical theory is almost dead in England; indeed it would appear as if the centre of gravity of this science had gone bodily eastward, and Berlin and St. Petersburg now replace London and Paris so far at all events as organic chemistry is concerned.

But if the chemist has ceased to employ physical tools this is made up for by those large fields of physical work which are being more and more utilised by the physiologist. The introduction of physical methods into biological research is one which has already borne, and which will in the future bear, rich fruit, and all work of one kind in this direction will be as largely modified in the future by the introduction of physical methods as that of another will be rendered practically a new science by the generalisations of the immortal Darwin.

All experimental science will gain by this, for each branch of scientific work reacts upon all others, and while in the future a physiologist who simply knows how to use a microscope and a dissecting knife will be an impossibility, physics, on the other hand, will be sure to receive new methods of observation and new instruments from those who have been compelled to invent them for their new needs.

We have recorded the completion of, perhaps, the greatest work ever undertaken and carried to a conclusion by any one man. We allude to the planetary tables, the final touches of which were added by Leverrier only a few hours before a death which has left a void in science which it may take centuries to fill.

The physical side of geology has attracted much attention during the last nine years, and it has been our privilege to chronicle many investigations dealing with the interior structure and heat and the probable age of our planet. The facts collected by our surveyors with an activity which, especially in America, has been something beyond all parallel, thus find themselves supplemented by theoretical views, the fitting together of which, in the future, will be a work which will be second to none in interest.

Of practical applications of science made since 1869 the number is legion, and some are of high order. The advance in navigation, perhaps, is the most striking. We have not only in the way of new instruments the bathometer, a machine for taking flying soundings, and a perfect compass, but also the whole art of navigation promises to be revolutionised by the introduction of new methods. One thing which all friends of science should take to heart, has been abundantly established, the science most applied is the science of which the theory is bound to receive the greatest development. The telephone, duplex telegraphy, steam fog-signals, and the application of electricity to lighting, must also be mentioned.

From the prosecution of science itself we must turn to some of its surrounding conditions. We have had to watch, and have recorded with pleasure, the establishment of several new societies, and the strengthening of old ones since our first number was issued. Mathematicians have now a strong society; physical science is now represented in this way by the side of chemistry; while the latest born of these societies, though by no means the least active, is that devoted to mineralogy. We do not suppose the coming time will see a very large increase in the number of these bodies, but we think that it certainly will see a considerable influence of them all upon the Royal Society. It would be a loss universally deplored if the Royal Society were to abate one jot or tittle of its influence, but with active societies all round it representing each branch of inquiry and at once discussing each advance of knowledge in full meetings, it is difficult to understand that the Royal Society may not suffer if some better method than the one at present adopted of providing for the reading of the multitude of papers presented to it is not adopted.

From our own English societies we once more come to individuals, and here our task is a sad one. It is almost impossible to name a period of nine years during which death has played such havoc among men of science of all nationalities. Herschel, Graham, Wheatstone, Sedgwick, Lyell, and Murchison are no more; Leverrier, the great Leverrier, has gone with Regnault, Milne-Edwards, Claude Bernard, Becquerel, and many other Frenchmen of note. America has lost Agassiz; Germany, Liebig, Argelander, Erdmann, Mayer, and Heis; Russia, von Baer and Mädler; Italy, Secchi; while in all countries the thinning of the ranks of men of lesser note has been disastrous. We may surely hope that in our new series the sad task of bidding farewell to men who have done their work in science may fall less frequently upon us.

EDITOR

THE AMERICAN STORM WARNINGS

THE interest excited in Europe, and particularly in England and France, by the weather predictions cabled by the *New York Herald* to its London Office during the past year (commencing February 14, 1877) proves that these warning messages are regarded as important to the interests of commerce, navigation, and agriculture. The generally expressed opinion as to their accuracy is a favourable one, and is justified, I believe, by the fulfilment of a very large percentage. Such a result of the first year's work affords me unqualified satisfaction. It represents all the success I aimed to attain, and much more than I hoped to win.

I will state at the outset that the carrying out of the whole project of warning the European coasts of the approach of storms has depended on, and has been sustained by, the munificence and generous enterprise of Mr. James Gordon Bennett, the proprietor of the *New York Herald*, whose encouragement and support of every undertaking calculated to promote the advancement of science and discovery are well known and appreciated. The work accomplished so far is the result of some years' study of the phenomena of atmospheric movements. The deductions, therefrom, I have endeavoured to reduce to a practical application in these cabled weather-warnings of the *New York Herald*. In this, I believe, a useful step has been made in meteorological inquiry, which may lead to greater and more definite results.

Before February 19th, 1877, the day on which the first weather warning of the *New York Herald* (sent on the night of the 14th) was fulfilled, the question as to the possibility of establishing a reliable connection between

the meteorological phenomena of the American and European continents was unsettled. In stating this I do not ignore the efforts previously made with that object by many scientific men in Europe, like the late M. Leverrier, Director of the Paris Observatory. In many scientific circles the possibility had long ago grown to be regarded as a probability, and public as well as private efforts were being constantly made toward a thorough investigation of the laws of atmospheric movement and of storms. Indeed the failures, so called, that attended these researches were, in reality, successes of the highest importance to meteorological science, because they taught the investigators to eliminate all that was worthless in theory, and pay closer attention to the simpler and grander facts of nature which direct and patient observation made apparent. The chief difficulty in the way of success lay in the limited area of the physical field of investigation. Local phenomena have been treated as general, and the observations made in a comparatively small district have been used to found the theories applied to a hemisphere.

Except in few cases, recent works on meteorology are barren of original information. They are chiefly mad up of quotations from earlier works, and the experiences of isolated observers who, straining after the establishment of narrowly based theories, permit their enthusiasm to lead them to false conclusions. This accusation may, and probably will, be levelled against myself, but I assure the critics that I will submit to any adverse judgment on my work that is based on scientific truth and feel grateful for the enlightenment. Whatever may be the value, or otherwise, of the statements I make, they are based upon personal observations, and depend in no way on the generally accepted meteorological theories with regard to the origin and movement of storms. I aim at winning for my work all that may be due to its merit, while I am willing to bear all the censure for its defects.

The importance to the interests already referred to of a system of weather predictions, which can be published for the general information of the people, several days in advance of the events they announce, is one that cannot be disregarded. We find in America that many branches of trade are seriously affected by weather changes, and that timely warnings are calculated to insure against losses that would, in their absence, be sustained. The great grain-growing districts of the Western States have their respective centres to which the produce is brought for sale, storage, and shipment to the eastern sea-board. Sudden and severe storms not only injuriously affect the condition of the roads and other lines of transportation, and thus delay shipments, but also the produce itself; and the anxiety of the farmer for the safety of his crops is equalled by that of the merchant whose capital is invested in that special branch of trade. Hence, both producer and dealer, as well as the transportation agent, anxiously watch the western horizon, and eagerly receive every item of information bearing on the all-important condition of the weather. The same state of feeling must exist wherever trade flourishes and agriculture represents wealth. Whether the corn be stored in a Chicago elevator ready for shipment to Europe, is borne by the steamship across the Atlantic, or is stored at the centres of consumption in England and France, the conditions vary only in degree. The cotton-fields of the Southern States, the cotton ships on the ocean, and the staple stored in the warehouses of Liverpool or Manchester are under the same all-pervading influence of the weather.

To the seaman the timely storm warning is of paramount importance. Whether he threads his dangerous course among narrow channels along the coasts, or sails boldly into the broad ocean, the foreknowledge of an approaching storm causes him to adopt those precautions which insure his safety. The dreadful story of shipwreck which has been continued through the annual chapters of the past twenty-five years, will reach its hoped-for "*Finis*," when meteorological science effectually aids the nautical skill of the mariner in warding off the great dangers of the sea. Then the headlands of every coast will have their signal stations, and the sailor when taking his parting look at the land he is leaving, or getting his first of that he approaches, will see the warning signal that shall tell him of coming storms, and bid him prepare to meet them.

In many other respects the value of timely storm signals will be immense. Take, for instance, the case of an army on campaign. The general commanding mus regulate his movements as much by his facilities for transportation and supply as by strategic necessities. He must cross rivers and wade through marshes; climb and hold rugged mountain passes; and secure his communications by substantial bridges and practicable roads. His supplies must be largely drawn over difficult routes, and, perhaps, from districts liable to inundations and heavy snow or rain storms. If he relies on a co-operating fleet, the ships must be guarded against storms in exposed anchorages. In a word, the variations in the conditions of the weather must be recognised in all the operations of an army, otherwise great disasters may overtake it, notwithstanding the valour and endurance of the troops and the skill of the commander. I have watched with the greatest interest the progress of the recent campaign in Bulgaria, and have frequently announced in New York many days in advance the changes of weather that impeded the Russian progress, endangered the Danube bridges, and filled the Balkan passes with snow. Such calamities as befell Napoleon in 1812, and a portion of the allied forces in the Crimea in 1854–55, would have been avoided if a meteorological service existed at those times to give warning of the weather changes that produced them.

If a special military service of meteorologists, such as the United States enjoys in its Signal Service Corps, was organised in European armies, many of the difficulties incidental to warfare on that continent could be provided against. But as the foundation of such a system must rest on the accuracy of weather predictions by cable from America, the duties of an Army Signal Corps in Europe with relation to the weather would be simplified to a close observation of the western and southern coasts or frontiers, and the forwarding of information to the proper points. At the present time the European western coasts cannot receive by local observations what can be called timely storm-warnings in the strict sense of the term. The British Channel, the German Ocean, the Baltic, and

West Mediterranean, which represent the chief commercial areas of home navigation, are near the points where the first weather indications present themselves. It is not surprising, therefore, that notwithstanding the vigilance of coast-observers, and the prompt distribution of warnings from London and Paris, that many vessels are overtaken and fairly surprised by storms within sight of the British and French coasts. The *New York Herald* warnings have been forwarded to lessen this danger to navigation in European waters, as well as to give notice of bad weather in the Atlantic to vessels bound for our coasts.

I shall first deal with the field of observation from the West Pacific Ocean to the Ural Mountains.

I will limit my remarks on the general and local phenomena of storms, to which the *New York Herald* system of cable weather predictions relates, to the field of observation that extends from the western part of the Pacific Ocean in a great but irregular zone, eastward to the line of the Ural Mountains.

The irregularity in the width of this field which lies generally between the 10th and 70th parallels of northern latitude is caused by our want of information regarding the meteorology of the far northern sections of this continent and of the region in North Africa between the equatorial zone and the northern limit of the great desert of Sahara.

While the prevailing conditions in these regions may be correctly inferred from their relations to contiguous territories, it will be unsafe for the present to base any assumptions thereon, especially when such are not absolutely necessary for my purpose in this article. I will therefore refer only to the Pacific Ocean, between the 10th parallel and the Aleutian Islands, the North American continent between the same parallel, and the regions of Manitoba and north of the great lakes and Canada; the Atlantic between a line drawn from the intersection of the 40th meridian and the 10th parallel, to the African coast at Cape Blanco; and the line drawn from Cape Farewell, in Greenland, and the North Cape, in Norway; and Europe between the 30th and 70th parallels.

This immense area contains two great oceans familiar to navigators, and the two continents that represent in the majority of their peoples, the commercial enterprise, the power, and the intelligence of the world. It also represents a considerable portion of the earth's surface subjected to a diurnal and equal share of solar influence according to latitude. Whatever may be the real effect of the sun's heat and magnetism in producing atmospheric perturbations, the field selected is that which they must almost uniformly influence, and on which the extent of that influence is most likely to be accurately determined by scientific observation and study.

It will be observed that the oceanic and continental areas are each divided into two sub-areas by well-marked lines; the oceans by equatorial currents having a general direction from south-west to north-east, and the continents by distinct regions of mountain and plain. The distinction in the latter case is most marked on the North American continent, but is also very clearly defined in Europe. We have therefore eight sub-areas of the field of observation, each exercising its peculiar influence on the movement of the atmosphere over the whole field. The *Kuro Siwo* or Japan current of the Pacific Ocean, which corresponds so closely with the Gulf Stream in the Atlantic, moves north-eastward with a smaller resistance from the north polar waters than the Gulf Stream. The narrow Behring Strait, through which the Arctic current must pass southward is even narrower than Smith Sound, consequently the northern waters of the North Pacific maintain a higher general temperature than those of the North Atlantic, but owing to the spreading out of the *Kuro Siwo* over a greater area than the Gulf Stream covers in corresponding latitudes, the waters of the latter are relatively warmer and probably deeper between latitudes 30° and 60°. Hence a more uniform temperature overspreads that part of our field of observation represented by the North Pacific Ocean. It is reasonable to suppose that the compensatory flow of polar water toward the equator comes chiefly from the Antarctic regions in the Pacific Ocean and in nearly equal proportions from both poles in the Atlantic. The effect therefore must be, as I suggest, that the surface of the North Pacific has a very uniform temperature, making due allowance for latitude. The atmospheric conditions are consequently affected so far as to promote the development of large areas of low pressure without many important centres of very violent disturbance. I cannot say if the infrequency of storm centres, as we are accustomed to regard them, on the Pacific, suggested the name, but it cannot be considered an inappropriate one. Violent storms cross the northern parts of this ocean, but they come from the Asiatic continent, and are probably identical with those which had already passed over Northern Europe in their eastward courses. We have no satisfactory evidence that such storms again pass over Europe, but they undoubtedly traverse the circumpolar seas, carrying to those regions the great winds and snows that are experienced by whalers and explorers in the far north.

Over such an immense area of warm water surface as the Pacific presents the atmosphere absorbs an extraordinary evaporation, and in its general eastward movement brings the humid air to the western coast of the American continent, where, by condensation against the mountain chains that extend from Lower California to the Arctic Ocean, it becomes deposited in heavy rains. The liberation of latent heat consequent to this process causes a barometric fall near the coast line, and the development of storm centres which move inland over the Continent, and have been traced from Oregon to Armenia. Cyclones that are developed in the equatorial zone of the Pacific cross the ocean and are experienced on the American coast from latitude 20° to 55°, according to their point of origin, and high or low trajectories. The movements of these storms will be referred to under another head.

On the North American Continent the mountain sub-area extends eastward from the Pacific Coast to the line of the Rocky Mountains. It is represented by a great elevated plateau from four to eight thousand feet above the sea-level, and from three to six thousand feet above the general level of the sub-area of the plains which extends eastward from it to the Atlantic. The peculiar alignment of the axes of the mountain chains running

over this great plateau presents them as direct obstructions to the eastward movement of storms, and their influences on the latter are very marked. Indeed the most interesting study in American meteorology is that of the modifications produced by the great mountain plateau of the west, or the disturbances passing over it. The sub-area of the plains is that in which some of the most remarkable phenomena of storms are observed. The valleys of the Mississippi, Missouri, and Ohio, and the basins of the lakes and Gulf of Mexico are the theatres of tremendous storm movements, and are consequently the favourite areas for observation chosen by American meteorologists. Within them are experienced nearly every type of storm that traverses the Atlantic toward Europe. Unlike the sub-area of the mountains to the westward, that of the plains is favoured with an abundant rainfall which renders the great expanse fertile in nearly all its sections. The growths of the tropics flourish in the south, and productiveness marks its various climatic zones until the vast pine forests of the north define the agricultural limits. The contrast between the two sub-areas is extraordinary, yet their widely different conditions are easily accounted for when their respective meteorological aspects are studied. The Gulf of Mexico, with its accumulation of tropical waters, plays a very important part in creating the prevailing weather conditions of the sub-area of the plains. From it flows a continuous current of warm humid air, which supplies moisture and energy to the storms that descend from the regions of the north-west into the great river valleys. It is the cradle of the equatorial current that sweeps across the ocean far into the Arctic seas, carrying warmth and verdure to latitudes in Europe far north of the general habitable limit on the American continent. But it is unnecessary to do more than refer to so familiar a region in describing briefly the natural subdivisions of the field of observation.

For the Atlantic, like the Pacific, we have the dividing line of the equatorial current of the Gulf Stream. North and west of that line the surface temperature is low, south and east of it very uniform, and along it high. Air in motion over these surfaces is consequently affected by rapid variations of temperature, which affect in turn the energy of the disturbances traversing the atmospheric volume.

A very marked effect of this kind is produced when storms leave the Nova Scotia coast, and at once commence to pass over the equatorial and Polar counter currents. The pressure falls rapidly, and great gales are induced, but the storm seems to be held for several hours over the region between Nova Scotia and Newfoundland, as if controlled by forces which it strove to overcome. When fairly past Cape Race the movement of the storm is no longer interrupted by the influences of the currents, and makes a very uniform progress towards Europe. When cyclonic storms reach the Florida or Carolina coasts from the Gulf of Mexico their energy seems to be increased when passing over the Gulf Stream, but their courses are not altered very much by the influence of that current. This is probably due to its narrowness when passing along the coast to latitude 35°. Eastward of the Gulf Stream, and over the oceanic region of uniform surface temperatures the energy of the storms decreases somewhat, and the areas of their depressions increase. But on approaching the west coasts of Europe the storms again resume their forces and deposit heavy rains. Europe, like America, is divisible into two sub-areas, one of mountains and the other of plains. The eastern limit of the former is that of a line following the Scandinavian Mountains toward the Alpine development into Saxony, thence following the Carpathian mountain outline, and passing southward over Bulgaria and the Balkans to the Syrian mountains. The irregularity of such a dividing line is very apparent, but we may assume that given to be correct enough for our purposes. In crossing the Scandinavian Mountains, Atlantic storms invariably deposit a great rainfall over Norway and pass into the Gulf of Bothnia and Eastern Russia with a reduced precipitation. When on the great Muscovite plains the storms again increase in area, just as they do in the valley of the Mississippi after crossing the Rocky Mountains in Montana; the break in the dividing-line between the sub-areas of mountain and plain in Europe represented by the Baltic and the low lands of Northern Germany, forms a storm gateway to the interior plains, which is frequently passed by Atlantic disturbances. The mountain systems of Switzerland, Italy, and the Balkan peninsula, perform important parts in modifying the conditions during storm movements in Northern Europe, and have each their peculiar local influences on the weather. If these mountains did not form barriers between the regions of great evaporation with their humid winds from the south, and those of Northern and Central Europe, a parallel between the meteorological phenomena of the Mississippi Valley and those of Eastern and Southern Russia in Europe could be drawn very easily. Having now roughly sketched the field of observation at present available, and suggested here and there a few points worthy of special consideration, I will endeavour in the next article to explain how storms move over the several sub-areas, and the changes they undergo in each.

JEROME J. COLLINS

(To be continued.)

NEWCOMB'S ASTRONOMY

Popular Astronomy. By Simon Newcomb, LL.D., Professor U.S. Naval Observatory. (London: Macmillan and Co., 1878.)

A WORK on popular astronomy by an author so distinguished in the higher branches of the science as Prof. Newcomb, will be welcomed with more than ordinary interest. The main object of the present volume is to present the general reader with a condensed view of the history, methods, and results of astronomical research, especially in fields of most popular and philosophical nature at this epoch, in such language as to be intelligible without mathematical study; it has not been designed to instruct either the professional investigator or the special student of astronomy.

In his first chapter the author briefly treats of the phenomena of diurnal motion, the motion of the sun amongst the stars, the precession of the equinoxes, of the moon's motion, and of eclipses of the sun and moon, concluding with some account of the calendar. In his